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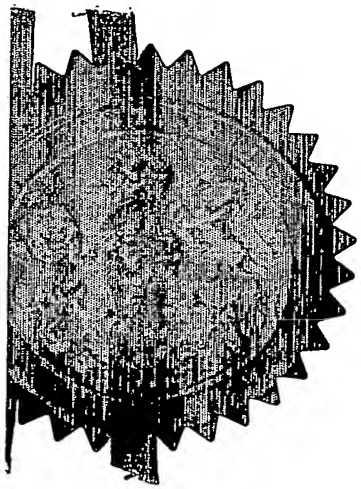


Signed Andrew Gerry

Dated 16 December 2003

Patents Form 1/77

Request for grant of a patent

1. Your reference	SJW/37453.GBA	
2. Patent application number	0226706.0	15 NOV 2002
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Magnesium Elektron Limited The Victoria, Harbour City, Salford Quays, Manchester M5 2SP	
Patents ADP number	58248 2003	
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom	
4. Title of the invention	COMPOSITE SACRIFICIAL ANODES	
5. Name of your agent *(if you have one)*	Raworth Moss & Cook	
"Address for service" in the United Kingdom to which all correspondence should be sent	Raworth House 36 Sydenham Road, Croydon, CR0 2EE	
Patents ADP number	1362001	

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number	Date of filing

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	
8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer yes if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant* *c) any named applicant is a corporate body*	YES

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document.

Continuation sheets of this form	-
Description	5
Claim(s)	3
Abstract	
Drawing(s)	2 only RM

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application

Signature [signature] Date 14 November, 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

Raworth Moss & Cook, Stephen J. Wise
020 8688 8318

COMPOSITE SACRIFICIAL ANODES

The invention relates to composite sacrificial anodes, particularly but not exclusively, based on magnesium, and to a method for their production.

Magnesium or magnesium alloy sacrificial anodes have been used for many years to provide cathodic corrosion protection for iron and steel engineering products, particularly in the oil industry. This technique is used to protect pipelines, marine oil installations, ships and other large steel constructions.

The corrosion protection provided by the anode can be measured in two ways. The Potential (voltage) of the anode, and the output capacity of the anode measured as amp-hours per kilogram of magnesium alloy.

There are at present three commonly used magnesium alloys that meet ASTM B843-93, namely magnesium with 0.5-1.3% manganese which produces a voltage of 1.7V, magnesium with 5.3-6.7% aluminium, 2.5-3.5% zinc and 0.15-0.7% manganese, and magnesium with 2.5-3.5%, aluminium 0.6-1.4% zinc and 0.2-1.0% manganese which produces a voltage of 1.5V.

The output capacity is affected by both the alloy used and by the method of manufacture of the anode. In particular, the cooling rate of the metal during solidification has been found to be important. (Juarez-Islas et.al 1993). The theoretical value for the output capacity for magnesium alloys is 2400 Ahr/kg. However it is reported that typical anodes are only 30-35% efficient.

Currently, 'D' shaped magnesium anodes of the type shown in accompanying Fig 1 are manufactured by casting magnesium alloys around a steel insert in an open top permanent mould, usually manufactured of cast iron. The insert provides both the mechanical and the electrical connection between the anode and the structure being protected. This method of manufacture typically results in a variable metal cooling rate both within individual anodes, and between anodes within a batch. In the case of large anodes, greater than 10 kg or very large anodes greater than 100 kg, the solidification rate in the centre of the anode will be substantially lower than that at the edge. This results in the electrochemical efficiency of conventional anodes being poor and variable.

This invention relates to a process which enables sacrificial anodes, particularly of magnesium or a magnesium alloy, to be produced which have improved performance with respect to output capacity, especially for large and very large anodes.

The present invention provides a method of producing a sacrificial anode having a protruding electrical connection which method comprises casting a plurality of segments of the sacrificial material each in contact with a respective portion of the electrical connection, each respective portion being at least partly within its corresponding segment and on the surface thereof, and joining the segments and their respective portions of the electrical connection together.

Preferably each segment is identical and are joined to each other, with any gaps between the segments being filled with a waterproof mastic or resin, to form a composite anode which may be cylindrical, square, rectangular or segmental in cross-section. In the most preferred embodiment each segment, of preferably a magnesium or magnesium alloy, is cast using direct chill (DC) casting technology. This is a method of manufacture currently used to produce magnesium slabs or billets as described in, for example, Grandfield, J. and McGlade, P. "DC Casting of Aluminium: Process Behaviour Magnesium Technology", Materials Forum Australia, Volume 20, 1996, p. 29-51. The preferred embodiment of the invention is a modification of this known production method to allow for the introduction of a steel insert into the cast magnesium or magnesium alloy billet or slab so as to produce an anode. This is shown schematically in Fig. 2, the insert being positioned off-centre near one of the walls of the mould aligned with the casting direction.

The off-centre insert, which is preferably a galvanised mild steel bar, protrudes from the casting so as to provide both a mechanical and an electrical connection to the structure to be protected. Generally a connector, such as a cable clamp, is integral with or else attached to an exposed or protruding part of the insert, for example by welding. A square cross-section anode made up of four continuously cast segments with a welded cable connector attached to its insert is shown in Fig 3. This insert is made up of the four off-centre bars of the four segments close together but not touching along their lengths inside the anode. Each bar preferably extends through the whole length of its respective segment and is connected at each end to the other three bars where they are exposed or protrude from their segments by welding.

To one of the welded joins the cable connector is welded, and at both ends of the composite insert the welded joins are covered by the mastic with only the cable connector exposed. The continuous casting of anodes is described in more detail in our co-pending application entitled "Improved Sacrificial Anodes" filed under reference "SJW/37452.GBA".

This method of production enables a uniform, controllable and rapid cooling rate to be applied to each segment by directly cooling with a water spray. This results in an improved electrochemical efficiency for the composite anode over a permanent mould cast anode of the same size.

Table 1 sets out the typical output capacity from a conventionally cast anode compared to that from an anode produced by DC casting.

Anode type	Energy capability(Ahr/Kg)
Conventionally Cast	1000
DC cast	1700

Table 1. Typical energy capability of conventionally vs. DC cast anodes.

The present invention is particularly suitable for fabricating very large anodes, e.g. over 100kg. By combining two or more anode sections together the composite behaves as one large anode. The sections used in the composite may be produced by DC casting or by conventional permanent mould casting. In either case, the fabricated anode produces an improved electrochemical efficiency over a single permanent mould cast anode of the same size since the cooling and solidification rates of the individual segments are faster and more controlled

than would be the case if the anode were cast in one piece.

The present invention also provides a sacrificial anode comprising a casting of a sacrificial material around a protruding centrally placed electrical connection wherein the casting is composed of a plurality of portions each having cast therein a portion of the electrical connection, and wherein the casting portions are joined together with their respective electrical connection portions being joined.

Preferably between two and six segments are joined together in such a way as to force the composite to act as a single anode.

The preferred composite anode consists of two or more segments together with the gaps filled with a waterproof mastic or resin as shown schematically in Fig 3. The inserts of each segment are linked together and sealed using preferably pitch. This causes the composite anode to corrode from the outside only, and hence provides the voltage and current flow equivalent to a single block.

CLAIMS

1. A method of producing a sacrificial anode having a protruding electrical connection which method comprises casting a plurality of segments of the sacrificial material each in contact with a respective portion of the electrical connection, each respective portion being at least partly within its corresponding segment and on the surface thereof, and joining the segments and their respective portions of the electrical connection together.

2. A method as claimed in claim 1 wherein each segment is identical.

3. A method as claimed in claim 1 or claim 2 wherein the segments are joined together by a waterproof mastic or resin.

4. A method as claimed in any one of the preceding claims wherein the sacrificial anode is cylindrical, square, rectangular or segmental and is composed of between two and six segments.

5. A method as claimed in any one of the preceding claims wherein each segment is formed by continuous casting.

6. A method as claimed in claim 5 wherein each segment is forcibly cooled.

7. A method as claimed in claim 6 wherein the cooling is effected by water.

8. A method as claimed in claim 7 wherein the casting is effected by direct chill casting.

9. A method as claimed in any one of the preceding claims wherein the sacrificial material is magnesium or a magnesium alloy.

10. A method as claimed in claim 9 wherein the sacrificial material is an alloy consisting essentially of magnesium and from 0.15% to 1.3% by weight of manganese.

11. A method as claimed in claim 1 substantially is hereinbefore described.

12. A sacrificial anode produced by a method as claimed in any one of the preceding claims.

13. A sacrificial anode comprising a casting of a sacrificial material around a protruding electrical connection wherein the casting is composed of a plurality of portions each having cast therein a portion of the electrical connection, and wherein the casting portions are joined together with their respective electrical connection portions being joined.

14. An anode as claimed in claim 13 wherein the casting portions are identical.

15. An anode as claimed in claim 13 or claim 14 wherein the casting portions are joined by a waterproof mastic or resin.

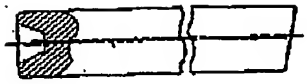
16. An anode as claimed in any one of claims 13 to 15 wherein the sacrificial material is magnesium or a magnesium alloy.

17. An anode as claimed in claim 16 wherein the sacrificial material is an alloy consisting essentially of magnesium and from 0.15 to 1.3% by weight of manganese.

18. An anode as claimed in claim 13 substantially as hereinbefore described.

19. An anode as claimed in claim 13 substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

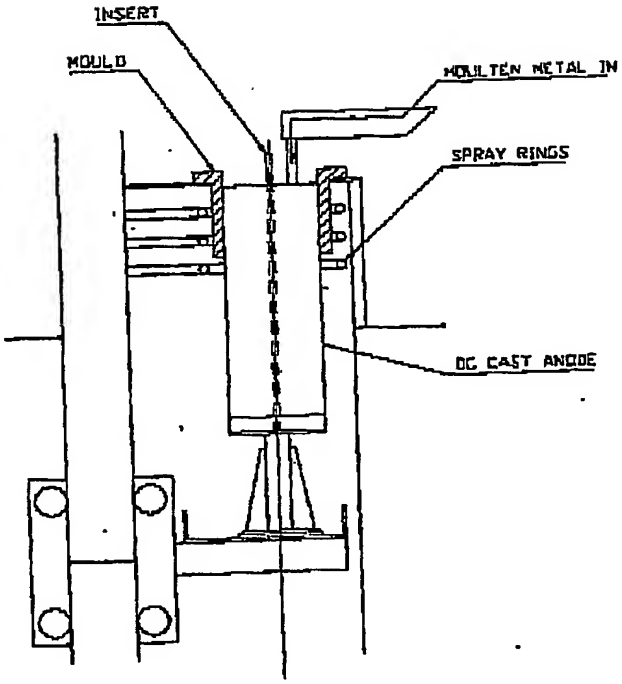
Figure 1



Side View

End View

Figure 2



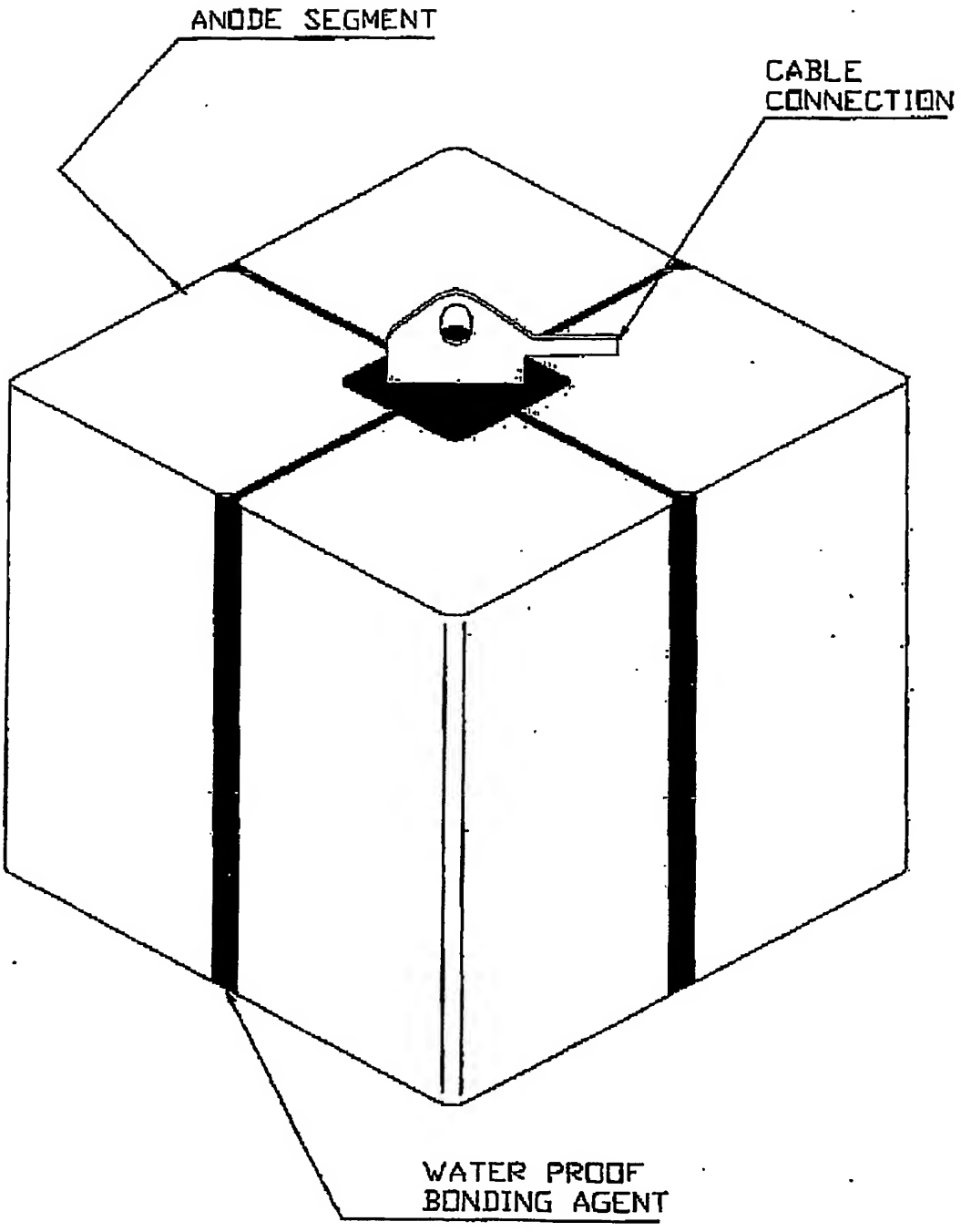


Figure 3